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UEDGE Simulations Of Detached Divertor Operation In DIII-D With a Chemically Sputtered Carbon Source*

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UEDGE simulations which include chemically sputtered carbon from the walls match multiple diagnostic data from DIII-D detached divertor operation much better than simulations with divertor plate sputtering only. Intrinsic carbon impurity is a pervasive source of radiated power in DIII-D. We use the 2-D fluid plasma code UEDGE to explore the effect of various carbon sources. The code is run in a multi species mode which includes each ionization state of carbon, along with the working deuterium species. We describe the results of a large number of steady state UEDGE calculations in which the chemical sputtering coefficient was systematically increased to explore the nature of the divertor plasma at various stages of detachment.

Simulations with sputtering caused by ion current to the plate alone yield detached plasmas at both the inner and outer plates as the sputtering coefficient is increased. However, the simulated radiation power saturates at levels well below that seen experimentally, and the ionization front (defined as the 5 eV electron temperature contour) remains close to the plates in the simulations, whereas it is seen as high as the X-point in experiments. When the sputtering coefficient is increased with both plate and wall sources of carbon, the plasma first detaches from the inner divertor, then the ionization front moves off the plate toward the X-point. The plasma detaches from the outer divertor when the ionization front on the inner leg approaches the X-point. The ionization front remains just below the X-point on the inner leg, and moves toward the X-point on the outer leg as the sputtering coefficient is increased further. The ionization front moves above the X-point on the inner leg as it approaches the X-point on the outer leg. Finally, running UEDGE in a time-dependent mode, we find a core MARFE forms when the ionization front in the outer leg moves above the X-point. This MARFE is characterized by a low temperature, high density region on closed flux surfaces just above the X-point. This region emits a large amount of power through carbon radiation, and a steady state solution is not obtained. This behavior is similar to that seen experimentally, as will be shown by a comparison between the simulations and a variety of diagnostic data, including divertor plate heating, divertor ion currents, 2-D profiles of line emission, line integrated emission spectra, and Thomson scattering measurements of electron density and temperature at the outer midplane and in the divertor region.

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